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Original Article

Social and Ecological Contributions of the Taungya Agroforestry System in the Restoration of Mount Elgon National Park, Uganda

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Agroforestry Systems, Taungya Farming, Conservation Incentives, Forest Restoration, Livelihood Enhancement.

ABSTRACT

Balancing conservation objectives with the livelihood needs of local communities remains a significant challenge in the management of protected areas. The Taungya agroforestry system, introduced in Mount Elgon National Park, Uganda, in 2009, aims to address this issue by integrating forest restoration with agricultural production for food security. This study assesses the social and ecological contributions of the Taungya system in Kapkwata sub-county, Kapchorwa district, focusing on its impact on forest cover restoration, food security, income generation, and the provision of ecosystem services. Using a mixed-methods approach, data were collected from 240 participants selected through random sampling, supplemented by key informant interviews. Quantitative data were analyzed using SPSS, and qualitative insights were analyzed through thematic analysis. The results indicate that the Taungya system significantly improved vegetation cover, with the majority of participants reporting an increase in forest cover from 0-25% to 51-75%. The program also contributed to household food security and income generation, with participants cultivating crops like Irish potatoes, maize, and onions for both consumption and sale. Non-crop benefits, including access to firewood and clean water, further enhanced household resilience. However, challenges such as small land allocations, crop pests, and wildlife conflicts were identified as barriers to maximizing the program's impact. To optimize outcomes, the study recommends increased land allocations per household and the introduction of integrated pest management strategies. The findings underscore the potential of agroforestry systems like Taungya to achieve sustainable conservation and community development in protected areas.

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INTRODUCTION

Protected areas have long been regarded as one of the most effective strategies for conserving biodiversity and safeguarding ecological resources (Feng et al., 2021; Brodie, 2024; Durmaz et al., 2024; Lu et al., 2006). However, the success of these areas is frequently undermined by growing human pressures, particularly from communities living within or adjacent to these regions. These pressures often lead to conflicts between local communities and protected area management due to restrictions on traditional resource use practices such as grazing, collection of non-timber forest products, hunting, and agriculture (Velempini & Garekae, 2024; Zaman et al., 2023; Hutton, Adams, & Murombedzi, 2005). This conflict is exacerbated by the socioeconomic vulnerabilities of these communities, many of whom rely heavily on the resources found in protected areas for their livelihoods (Roe et al., 2012). As a result, while the creation of protected areas may yield ecological benefits, it can also lead to significant economic hardships for local populations, often fostering negative attitudes towards conservation initiatives (Byaruhanga, Ahebwa & Ayorekire, 2012). These tensions frequently undermine the long-term sustainability of conservation efforts, highlighting the need for management strategies that address both conservation and livelihood objectives (Matose et al., 2024; Yuan et al., 2023).

To mitigate these conflicts, incentive-based conservation models have been introduced, aiming to align community interests with conservation goals by providing tangible benefits in exchange for local participation in conservation activities (Vira & Kontoleon, 2012). Various models such as community-based conservation (CBC), community-based natural resource management (CBNRM), and integrated conservation and development projects (ICDPs) have been implemented globally, often with varying degrees of success (Byaruhanga, Ahebwa & Ayorekire, 2012). The effectiveness of these approaches typically depends on their capacity to improve both community livelihoods and biodiversity conservation (Fidler et al., 2024; Koricha & Adem, 2024; Salafsky, 1999). Among these models, agroforestry systems—particularly the Taungya system—have emerged as a promising approach to balancing conservation and livelihood objectives (Hemida, Vityi, & Hammad, 2023).

The Taungya system, first developed in Myanmar and Burma in the 19th century, is a form of agroforestry that allows temporary cultivation of crops alongside trees in degraded forestland. Farmers are given access to forestland on the condition that they assist in forest restoration by planting trees, while also growing crops for food and income (Menzies, 1988). This system provides a dual advantage by promoting reforestation and enhancing the livelihoods of participating farmers

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through food security and income generation (Muthuri et al., 2023; Olatoye, Odedire, & Awotona, 2019; Imo, 2008). The success of the Taungya system in regions such as Nigeria, Ghana, Thailand, and China has demonstrated its potential to contribute significantly to both social and environmental outcomes (Appiah et al., 2020; Narh, 2024; Nigussie et al., 2020; Wiro & Ansa, 2019; Wiersma, 2022).

In Uganda, the Taungya system was introduced in Mount Elgon National Park in 2009 to address the severe deforestation and environmental degradation that had taken place between 1870 and 2008 (Opedes et al., 2022; Gizachew et al., 2018). Mount Elgon, one of Uganda's most ecologically important protected areas, is home to diverse flora and fauna and serves as a critical water catchment area (Bintoora, 2015). However, rapid population growth and agricultural expansion have exerted immense pressure on the park's resources, leading to deforestation, soil erosion, and habitat loss (Opedes et al., 2022; Gizachew et al., 2018). The Taungya system aims to reverse this degradation by engaging local communities in forest restoration efforts while simultaneously addressing their livelihood needs through crop production (Bintoora, 2015; Kenrick, 2023).

This study builds upon the previous research that evaluated the sustainability of incentive-based conservation models in the Mount Elgon Conservation Area, including the Taungya system (Mukosha, Lubowa & Nakizito, 2024). While that work focused on the sustainability challenges and broader incentive structures of the Taungya system, this study explores the system's social and ecological contributions, particularly its impact on forest restoration and community resilience. Specifically, this study assesses the system's effects on forest cover restoration, food security, income generation, and other ecosystem services, providing a more detailed understanding of its role in enhancing community livelihoods and biodiversity. By focusing on the social and ecological dimensions of the Taungya system, this research aims to fill the gap in the existing literature and offer evidence-based recommendations for improving the effectiveness of agroforestry as a tool for achieving both conservation and socioeconomic objectives in protected areas.

METHODOLOGY

The study was conducted in Mount Elgon National Park (MENP), a protected area covering approximately 110,971 hectares across eight districts in eastern Uganda. Located between 0°52′ and 1°25′ N and 34°14′ and 34°44′ E, MENP holds significant ecological value as a biodiversity hotspot and a crucial water catchment area. The park's largest portion falls within Bukwo district (26%), followed by Kween (17%) and Bulambuli (13%). Over 50% of Bukwo and significant portions of Bududa (41%) and Kapchorwa (36%) districts are designated as protected areas within the park. However, decades of human activities, including deforestation and agricultural encroachment, have caused severe environmental degradation.

A mixed-methods research design was adopted to comprehensively assess the social and ecological benefits of the Taungya agroforestry system, allowing for a more nuanced understanding of both measurable outcomes and participant experiences. The study employed a cross-sectional case study approach, integrating both retrospective and prospective data collection. Quantitative data were obtained through household surveys, while qualitative insights were gathered from key informant interviews. The study population consisted of 600 participants involved in the Taungya conservation program across 11 villages in Kapkwata sub-county, Kapchorwa district. These participants were local community members engaged in agroforestry under the Uganda Wildlife Authority (UWA)-facilitated initiative. A sample size of 240 participants was determined using the Yamane formula (Yamane, 1967), with a margin of error of 0.05 to ensure a statistically reliable representation of the larger population. The formula

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is $n = N/1 + Ne^2$ where 'n' represents the desired sample size, 'N' represents the population size (target population) which was 600 beneficiaries in the program and e^2 represents the degree of freedom/level of precision which is 0.05. (Yamane, 1967).

Sampling techniques included both simple random sampling and purposive sampling. For the household surveys, simple random sampling was employed using a lottery method to ensure every participant had an equal chance of selection, reducing bias in the sampling process. A total of 240 participants were randomly selected from the 600 available participants. For the key informant interviews, purposive sampling was used to select individuals with in-depth knowledge of the program. Key informants included Uganda Wildlife Authority (UWA) officials and local leaders who were directly involved in the management and oversight of the Taungya system.

Data collection involved two primary methods. First, structured questionnaires were administered to the 240 selected participants to gather quantitative data on crop yields, household income, food security, and perceptions of the Taungya system's benefits. The questionnaires were designed to capture both objective measures of livelihood changes and subjective evaluations of the program's impact. Second, semi-structured interview guides were used during key informant interviews to elicit qualitative insights. These interviews focused on the challenges, successes, and broader implementation of the Taungya system, particularly in the context of forest restoration and socio-economic improvements.

Quantitative data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 20.0. Descriptive statistics, including frequencies and percentages, were used to summarize demographic and outcome data. Inferential statistics, specifically chi-square tests, were applied to test the relationships between variables such as participant demographics and their perceptions of the program's benefits, allowing for the assessment of statistical significance. For the qualitative data, thematic analysis was conducted. Transcripts from the key informant interviews were carefully reviewed, and common themes were identified, categorized, and triangulated with the quantitative findings. This process provided a holistic understanding of the program's social and ecological impacts.

Ethical approval was obtained from the relevant institutional review board prior to data collection. Informed consent was secured from all participants before their involvement in the study. Participants were provided with information sheets that detailed the study's purpose, their rights as participants, and the voluntary nature of their participation. Verbal and written consent was obtained to ensure comprehension, and participants were assured that they could withdraw from the study at any point without consequence. To protect confidentiality, all participants were assigned identification numbers, and personal identifiers were removed from the data. Responses were anonymized in all reports and publications, and data were securely stored to prevent unauthorized access.

RESULTS

Background characteristics of respondents

A total of 240 participants were surveyed, consisting of 168 males (70%) and 72 females (30%). The household size varied, with the majority of households (43%) comprising 11-15 members, followed by 41% with 1-5 members, and a smaller proportion (15%) with 6-10 members (Table 1). These demographics are important in understanding the family structures that influence labor availability and overall participation in the Taungya system. Larger households may have greater capacity to engage in agroforestry activities, contributing to both household food security and the restoration of forest areas.

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Table 1: Gender and Household Size Distribution of Taungya Program Participants

(a): Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Female	72	30.0	30.0	30.0
	Male	168	70.0	70.0	100.0
	Total	240	100.0	100.0	

(b): Household distribution

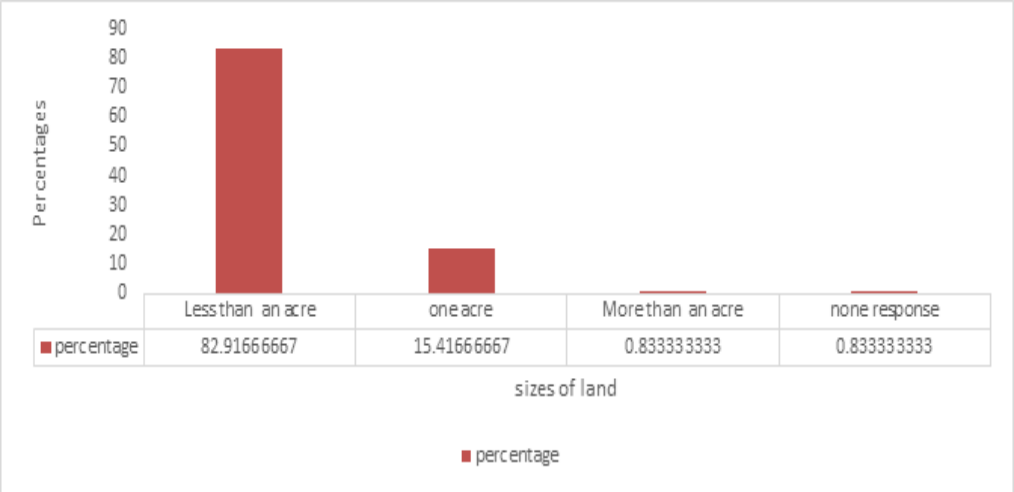
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Household size	2	1.0	1.0	1.0
	1 -5	98	41.0	41.0	42.0
	6 – 10	36	15.0	15.0	57.0
	11 – 15	104	43.0	43.0	100.0
	Total	240	100.0	100.0	

The table represents the gender composition and household sizes of the participants in the Taungya agroforestry program in Kapkwata sub-county, Kapchorwa district, Uganda.

Land Size Utilized for the Taungya Program

The majority of the participants (82.91%) practiced Taungya farming on plots smaller than one acre, while 15.41% had access to exactly one acre, and only 0.83% of participants cultivated on more than one acre (Figure 1). These findings highlight the limited land access that constrains agricultural productivity, which has implications for household food security and income generation, especially when small plot sizes limit crop diversification and yield potential.

Figure 1. Land Size Distribution of Taungya Program Participants.



The figure shows the distribution of land sizes cultivated by participants in the Taungya program, with the majority of participants farming on less than one acre of land.

Crops Grown and Annual Yields

The most commonly grown crops were Irish potatoes (93.33%), maize (82.08%), onions (77.50%), beans (67.91%), and carrots (39.16%) (Figure 2). Irish potatoes and onions produced the highest yields, with 68.33% of participants harvesting over 100 kg of Irish potatoes annually.

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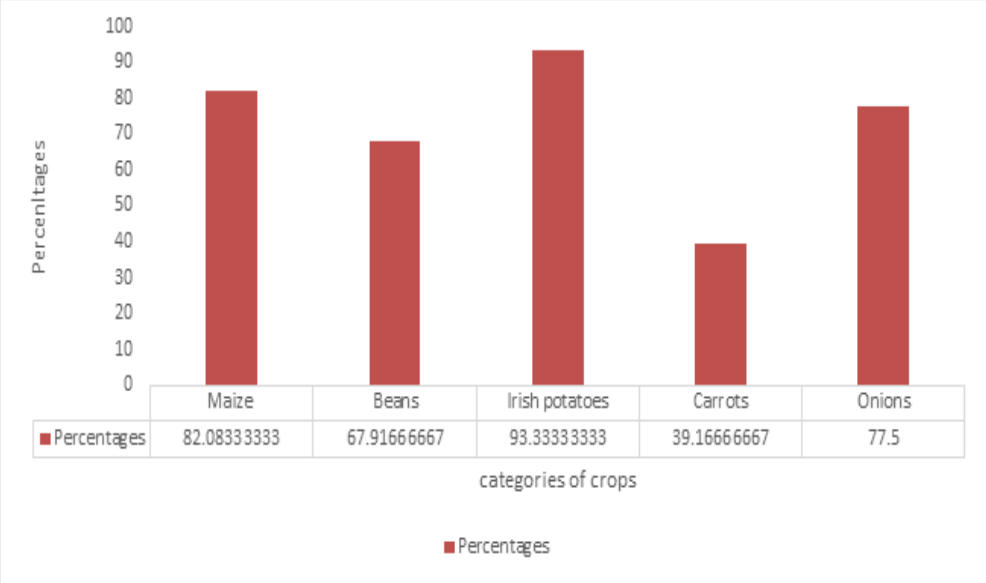
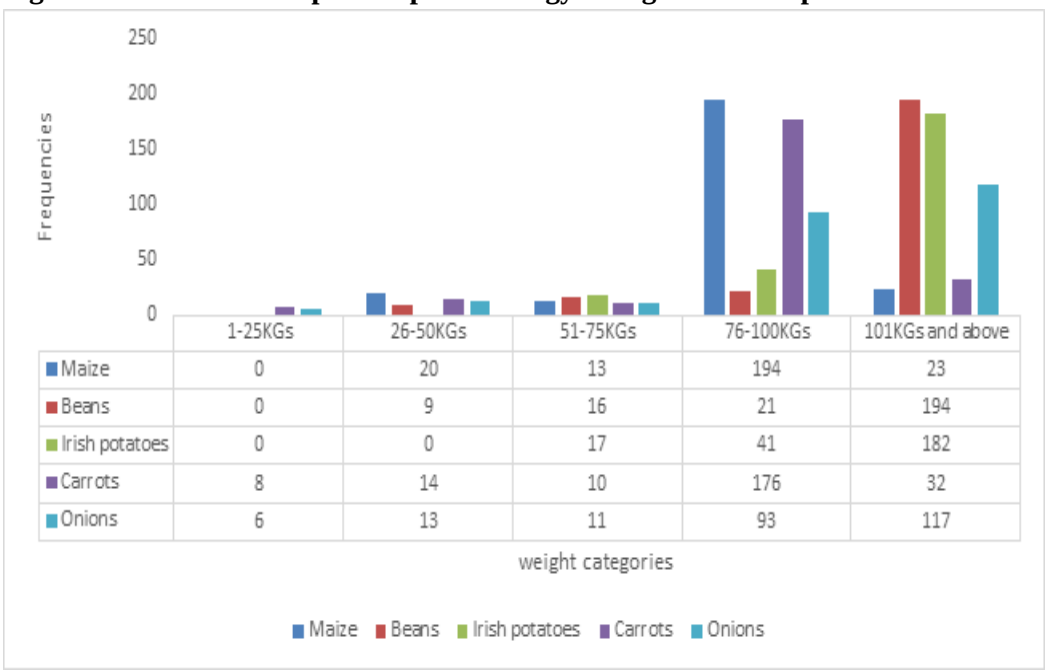
Conversely, beans, maize, and carrots generally had lower yields, with most participants reporting harvests of less than 100 kg (Figure 3). This variation in crop yields reflects the relative suitability of the land for different crops, as well as the influence of household labor allocation and agronomic practices on productivity.

Figure 2: Commonly Grown Crops by Taungya Program Participants.



The figure illustrates the frequency of different crops grown by participants in the Taungya program, with Irish potatoes being the most frequently grown crop, followed by maize and onions.

Figure 3: Annual Yields per Crop for Taungya Program Participants.



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Highlights that Irish potatoes and onions yield the highest quantities, while maize and carrots yield lower amounts

Utilization of Harvests

Most respondents (86.0%) reported that they used their harvests for both household consumption and sale, while 11.0% cultivated solely for sale, and 3.0% produced crops exclusively for household consumption (Table 2). Additionally, 54.0% of the respondents reported selling 100% of their harvest, while 43.0% sold more than half of their total yield. These findings suggest that the Taungya system not only contributes to food security but also provides a reliable source of income for the majority of participants. However, the reliance on crop sales for income indicates potential vulnerability to market fluctuations and crop failure risks.

Table 2: Utilization of Harvests and Sales by Taungya Program Participants

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Consume	7	3.0	3.0	89.0
	Sell	26	11.0	11.0	100.0
	Both	206	86.0	86.0	86.0
	Total	**240**	**100.0**	**100.0**	

Table shows how participants utilized their crop harvests, with most respondents using the harvest for both consumption and sale. It also shows the percentage of total crop yields sold by participants.

Economic Impact of the Taungya Program

The introduction of the Taungya system had a significant positive economic impact on participants. Prior to joining the program, the majority of participants (82 out of 86) earned less than 500,000 UGX annually. After their involvement in the program, 189 participants reported an annual income between 500,000 and 1,000,000 UGX, and 36 participants earned more than 1,000,000 UGX annually (Figure 4). This represents an average increase of 21.15% in economic benefits for participants, illustrating the system's potential to improve household income through sustainable agroforestry practices.

Figure 4: **Changes in Income Levels Among Taungya Program Participants.**

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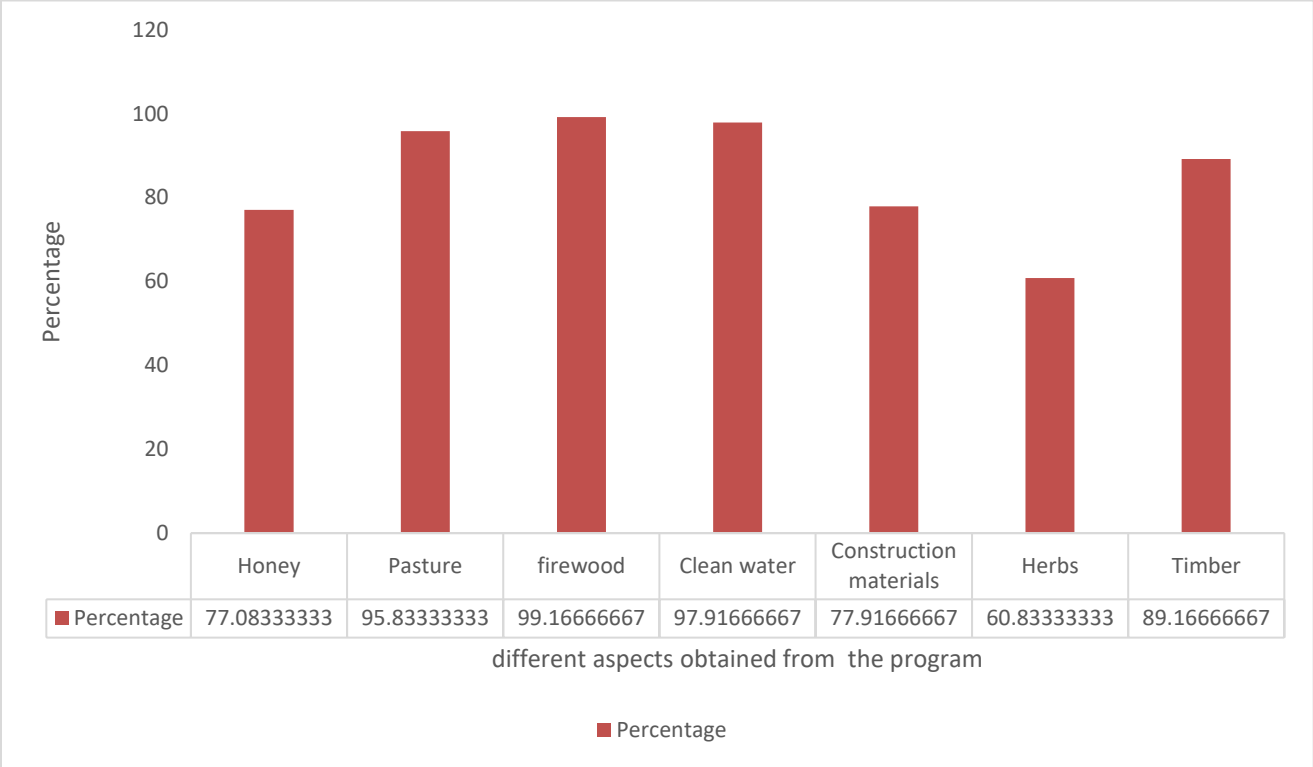
Illustrates the shift in income levels of participants before and after joining the Taungya program, indicating that the program significantly improved their annual earnings.

Non-Crop Benefits of the Taungya Program

Beyond direct crop production, participants benefited from additional ecosystem services provided by the Taungya system. These included access to honey (77.08%), firewood (99.16%), clean water (97.91%), pasture for animals (95.83%), and construction materials (77.91%) (Figure 5). These non-crop benefits play an important role in reducing reliance on protected area resources, supporting local livelihoods, and fostering positive community attitudes toward forest conservation.

Figure 5. Non-crop benefits obtained from the Taungya Program.



Additional benefits that participants gained from the Taungya program, including access to honey, firewood, clean water, pasture, and construction materials

Vegetation Cover Before and After Program Implementation

Participants estimated the level of vegetation cover on their plots before and after the implementation of the Taungya system. Prior to the program, 49% of respondents reported that vegetation cover was between 0-25%, with only 7% estimating cover between 76-100%. After program implementation, vegetation cover improved significantly, with 68% of respondents reporting cover between 51-75% and 18% reporting cover between 76-100% (Table 3). These results indicate that the Taungya system has contributed to successful reforestation and ecosystem restoration in the park.

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Table 3: Changes in Vegetation Cover Before and After Taungya Program Implementation

(a) Before Program Participation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0-25%	118	49.0	49.0	49.0
	26-50%	86	36.0	36.0	85.0
	51-75%	19	8.0	8.0	93.0
	76-100%	17	7.0	7.0	100.0
	Total	**240**	**100.0**	**100.0**	

(b) After Program Participation

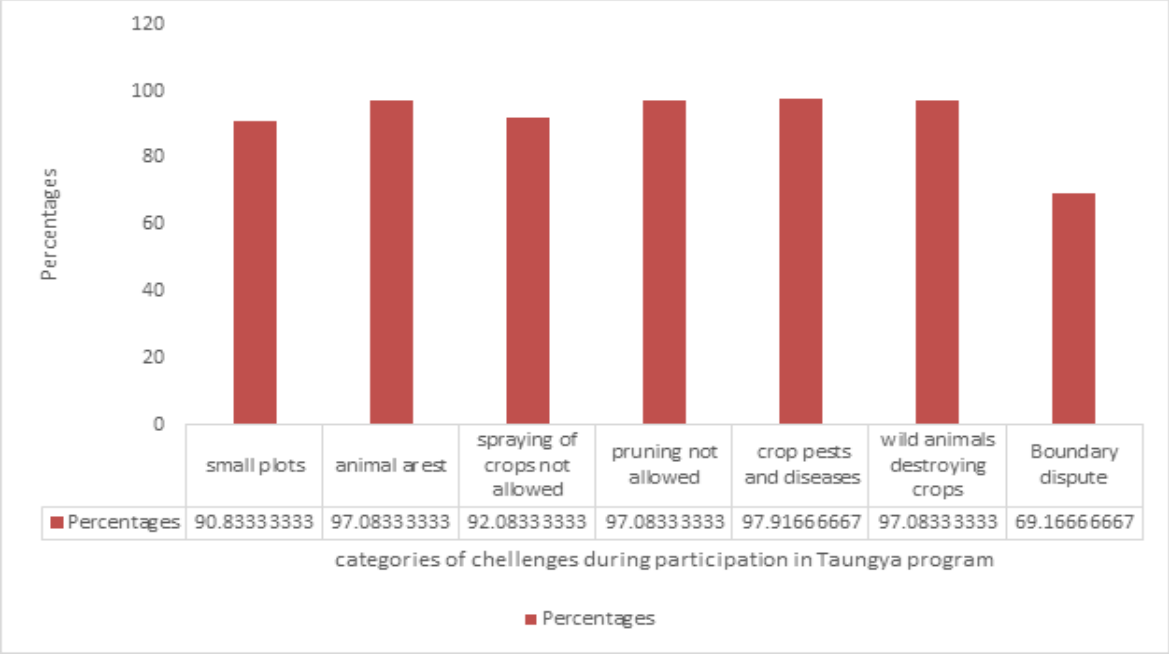
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0-25%	5	2.0	2.0	2.0
	26-50%	29	12.0	12.0	14.0
	51-75%	163	68.0	68.0	82.0
	76-100%	43	18.0	18.0	100.0
	Total	**240**	**100.0**	**100.0**	

This table presents the participants' estimates of vegetation cover before and after the implementation of the Taungya program, showing a significant increase in forest cover as a result of the program.

Challenges Faced During Participation

Participants identified several challenges encountered during their participation in the Taungya program, including crop pests and diseases (97.92%), wildlife crop destruction (97.08%), small land size allocations (90.83%), restrictions on spraying crops (92.08%), and disputes over grazing land (69.17%) (Figure 6). These challenges highlight the complexities involved in managing agroforestry systems within protected areas and underscore the need for enhanced support mechanisms to address these issues.

Figure 6. Major Challenges Encountered During Taungya Program Participation.



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Highlights the key challenges faced by participants in the Taungya program, including crop pests, wildlife destruction, limited land size, and restrictions on crop management practices.

DISCUSSION

The findings of this study demonstrate the critical role of the Taungya agroforestry system in balancing forest restoration with livelihood improvements for local communities in Mount Elgon National Park. This discussion explores both the social and ecological benefits derived from the program, while contextualizing the findings within broader literature on agroforestry and conservation practices. Furthermore, the challenges participants faced and potential areas for future improvements are addressed with support from recent studies.

Social Benefits of the Taungya Program

The Taungya system significantly contributed to food security and income generation for participants, with most households cultivating staple crops such as Irish potatoes and maize. These findings align with previous research indicating that agroforestry systems, including the Taungya model, provide critical support to household food security by integrating crop production with forest restoration (Muthuri et al., 2023; Zaman et al., 2023). For instance, Muthuri et al. (2023) found that agroforestry systems in East Africa enhanced both food production and community livelihoods, supporting similar conclusions in the present study. The dual-purpose nature of the Taungya system—allowing households to grow food while participating in reforestation—provides a strong incentive for continued community involvement in conservation activities.

In terms of income generation, the results of this study demonstrate that participation in the Taungya program resulted in significant economic benefits for households, with many participants reporting income increases of over 20%. These findings are consistent with previous studies in Nigeria and Sudan, where the Taungya system was found to boost rural incomes through sustainable agroforestry practices (Hemida, Vityi, & Hammad, 2023; Olatoye, Odedire, & Awotona, 2019). Similarly, a study in Ghana reported that the modified Taungya system increased household earnings by providing access to forestland for both crop cultivation and timber sales (Narh, 2024). The current study reinforces the importance of income diversification, particularly in rural areas where livelihoods are often precarious and dependent on subsistence agriculture.

Moreover, the non-crop benefits provided by the program, such as access to firewood, honey, and clean water, were highlighted as crucial for household well-being. These ecosystem services reduce the reliance on protected area resources, a finding that aligns with other agroforestry studies that emphasize the importance of non-timber forest products (NTFPs) in supporting rural livelihoods (Zaman et al., 2023; Wiro & Ansa, 2019). By offering additional benefits beyond crop production, the Taungya system promotes a holistic approach to resource management, contributing to both food security and environmental sustainability.

Ecological Benefits and Conservation Impacts

One of the most notable findings of this study is the improvement in vegetation cover following the implementation of the Taungya system. Participants reported significant increases in forest cover, with many estimating vegetation cover to have increased from 0-25% to 51-75% or higher. This is consistent with global evidence on the positive role of agroforestry in forest restoration and biodiversity conservation. For example, Wiersma (2022) found that the modified Taungya system in Ghana successfully restored large areas of degraded forestland, and similar outcomes have been observed in other regions such as Thailand and China (Menzies, 1988; Yuan et al., 2023).

The reforestation efforts under the Taungya system not only enhance biodiversity but also contribute to critical ecosystem services such as soil stabilization

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and water retention. These services are vital for maintaining agricultural productivity and reducing the risk of environmental degradation (Feng et al., 2021). Additionally, the restoration of vegetation cover helps mitigate the effects of climate change by sequestering carbon, a benefit that has been emphasized in recent studies on agroforestry's role in climate resilience (Koricha & Adem, 2024). Thus, the current study highlights the Taungya system's dual impact: while contributing to forest conservation, it simultaneously supports the socio-economic resilience of local communities.

Furthermore, the reduction in pressure on protected area resources—such as firewood and grazing land—suggests that the program is successful in redirecting community needs toward more sustainable resource use. This is consistent with findings from studies on community-based conservation programs, which show that providing communities with alternative livelihood options can significantly reduce illegal activities, such as poaching and logging, that threaten biodiversity (Kenrick, 2023; Matose et al., 2024).

Challenges and Recommendations

Despite the successes of the Taungya system, several challenges were identified in this study that hinder its full potential. One of the major challenges reported by participants was the small size of land allocated for agroforestry, with most households cultivating less than one acre. This limited land size restricts the capacity for crop diversification and large-scale production, reducing the potential economic benefits for participants. Similar challenges have been noted in other agroforestry programs, where limited land access constrains both productivity and household resilience (Narh, 2024; Velempini & Garekae, 2024).

Another key challenge is the issue of crop pests and diseases, which affected nearly all participants. The prohibition on chemical pesticide use within the park exacerbates this problem, as it limits participants' ability to protect their crops. Studies have suggested that the adoption of integrated pest management (IPM) strategies, which combine biological pest control methods with sustainable agronomic practices, could mitigate crop losses while maintaining ecological integrity (Feng et al., 2021; Salafsky & Margoluis, 1999). Implementing IPM in the Taungya system could improve crop yields without compromising the conservation goals of Mount Elgon National Park.

Wildlife-crop conflicts, where wildlife invades agroforestry plots and damages crops, were also a significant concern for participants. This issue is commonly reported in agroforestry and community-based conservation projects, particularly in regions adjacent to protected areas (Okaka & Apil, 2017; Zaman et al., 2023). To mitigate these conflicts, stakeholders should consider establishing wildlife deterrents, such as fences or buffer zones, around agroforestry plots. Studies from other regions have shown that such measures can be effective in reducing crop damage from wildlife (Hemida et al., 2023).

Future Considerations for Program Improvement

Moving forward, several areas for improvement can be identified to enhance the effectiveness of the Taungya system in Mount Elgon National Park. First, addressing the issue of small land allocations is critical. Providing larger plots or improving land-use efficiency through sustainable intensification techniques would enable participants to increase their crop production and income. In addition, providing agricultural extension services to support the adoption of sustainable farming practices, including IPM, would help mitigate the challenges of pests and diseases.

Second, the ongoing issue of wildlife-crop conflicts needs to be addressed through community-driven solutions. Engaging local communities in the design and implementation of wildlife deterrents could foster greater cooperation between conservation authorities and participants, thereby reducing

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tensions and promoting long-term conservation goals.

Finally, further research is needed to assess the long-term impacts of the Taungya system, particularly in terms of its ecological contributions and socio-economic benefits. Longitudinal studies that track the evolution of forest cover, biodiversity, and community livelihoods over time would provide valuable insights for refining the program and ensuring its sustainability.

CONCLUSION

The Taungya agroforestry system has demonstrated its potential to balance conservation and livelihood objectives in Mount Elgon National Park. The program has contributed significantly to forest restoration, enhanced ecosystem services, and improved household food security and income generation. However, challenges such as small land allocations, crop pests, and wildlife conflicts limit the program's full impact. By addressing these challenges through expanded land access, integrated pest management, and wildlife deterrents, the Taungya system can continue to meet both conservation and livelihood goals sustainably. As the program evolves, continued monitoring and evaluation will be essential to ensure its long-term success and adaptability.

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Conflict of interest

The authors declare no conflicts of interest.

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